

# DESIGN OF RESIDUAL STRESS IN NANOCRYSTALLINE DIAMOND FILMS

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## Abstract

Nanocrystalline diamond films were deposited with an IPLAS CYRANNUS<sup>®</sup> plasma source. The functional principle of this microwave plasma source is based on a resonator with annular antennas. This special setup allows the use of plasma from low pressure ( $10^{-2}$  mbar) to atmospheric pressure (1 bar).

The nanocrystalline films shown here were deposited in a pressure range between 200 and 300mbar from an Ar/H<sub>2</sub>/CH<sub>4</sub> plasma. The films were characterized by two wavelength scanning micro Raman spectroscopy, SEM and AFM measurements.

Since the C<sub>2</sub> carbon dimers are believed to be the growth species for nanocrystalline diamond films the deposition rate was optimized using optical emission spectroscopy. The emission intensities of the C<sub>2</sub> dimer at 515nm from the microwave plasma correlates linearly with the absolute C<sub>2</sub> concentration in Ar/H<sub>2</sub>/CH<sub>4</sub> plasma [1] and can therefore be maximized by varying the CH<sub>4</sub> concentration, the pressure and the gas flow. A correlation between the amount of C<sub>2</sub> in the plasma and the deposition rate is shown.

Residual stress is a critical parameter in thin film deposition and especially important for technical applications of nanocrystalline diamond films like tribological coatings or MEMS. High residual stress can lead to cracking or even to delamination of the film from the substrate. An ex-situ optical device (SSIOD "Surface Stress Induced Optical Deflection") was used to measure the curvature of silicon substrates coated with nanocrystalline diamond films. With respect to Stoney's equation one can calculate the residual stress from the curvature of the substrate. It is shown that the residual stress in the substrate can be varied in a wide range from compressive to tensile stress just by changing the gas flow of the process gas without changing the gas composition or the pressure.

Birell et al. [2] have proposed that the 1120 cm<sup>-1</sup> and 1450 cm<sup>-1</sup> peaks in the Raman spectra are due to carbon-hydrogen bonds in the grain boundaries of nanocrystalline films. In this work a correlation is made between the residual stress measurements and the Raman spectra of nanodiamond films. It is shown that the spectra of films with low residual stress feature clearly visible peaks at 1450 cm<sup>-1</sup> and at 1120cm<sup>-1</sup>.

## REFERENCES

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